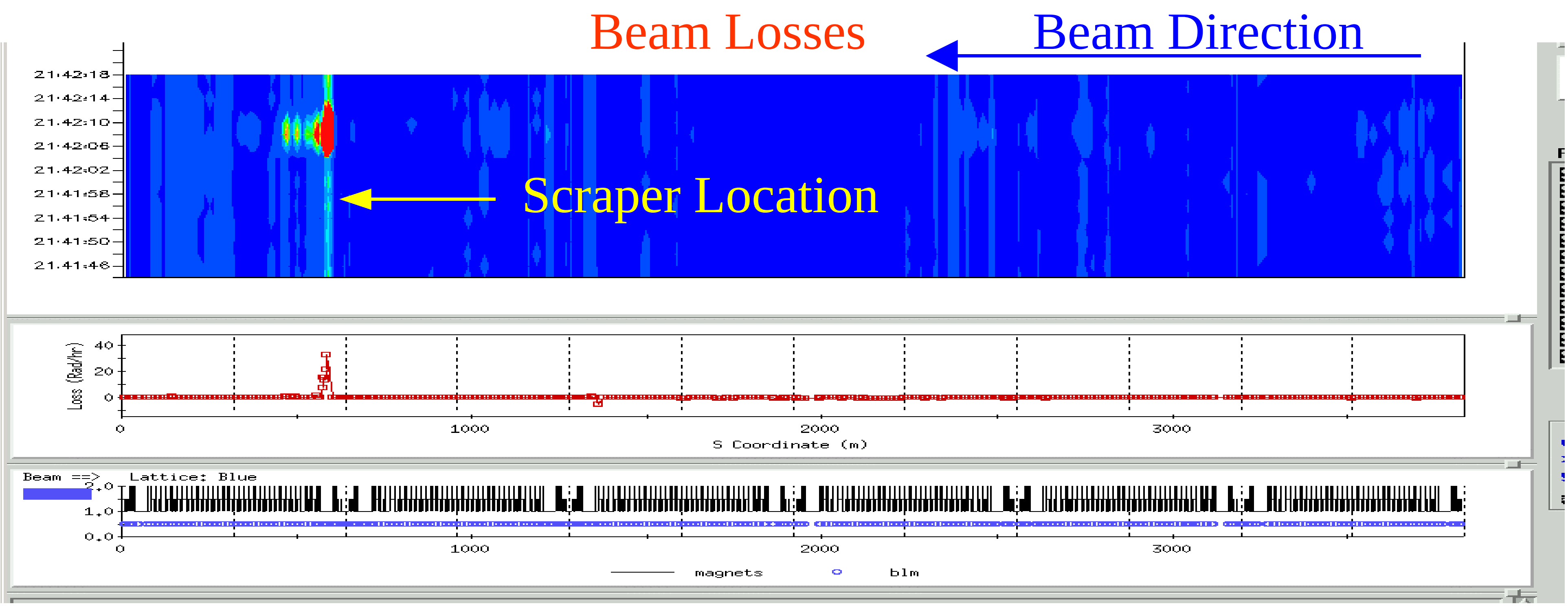
Collimation

- Benchmarking
- Cleaning Efficiency and lessons to be learned for the LHC
- Steering Algorithms and Procedures

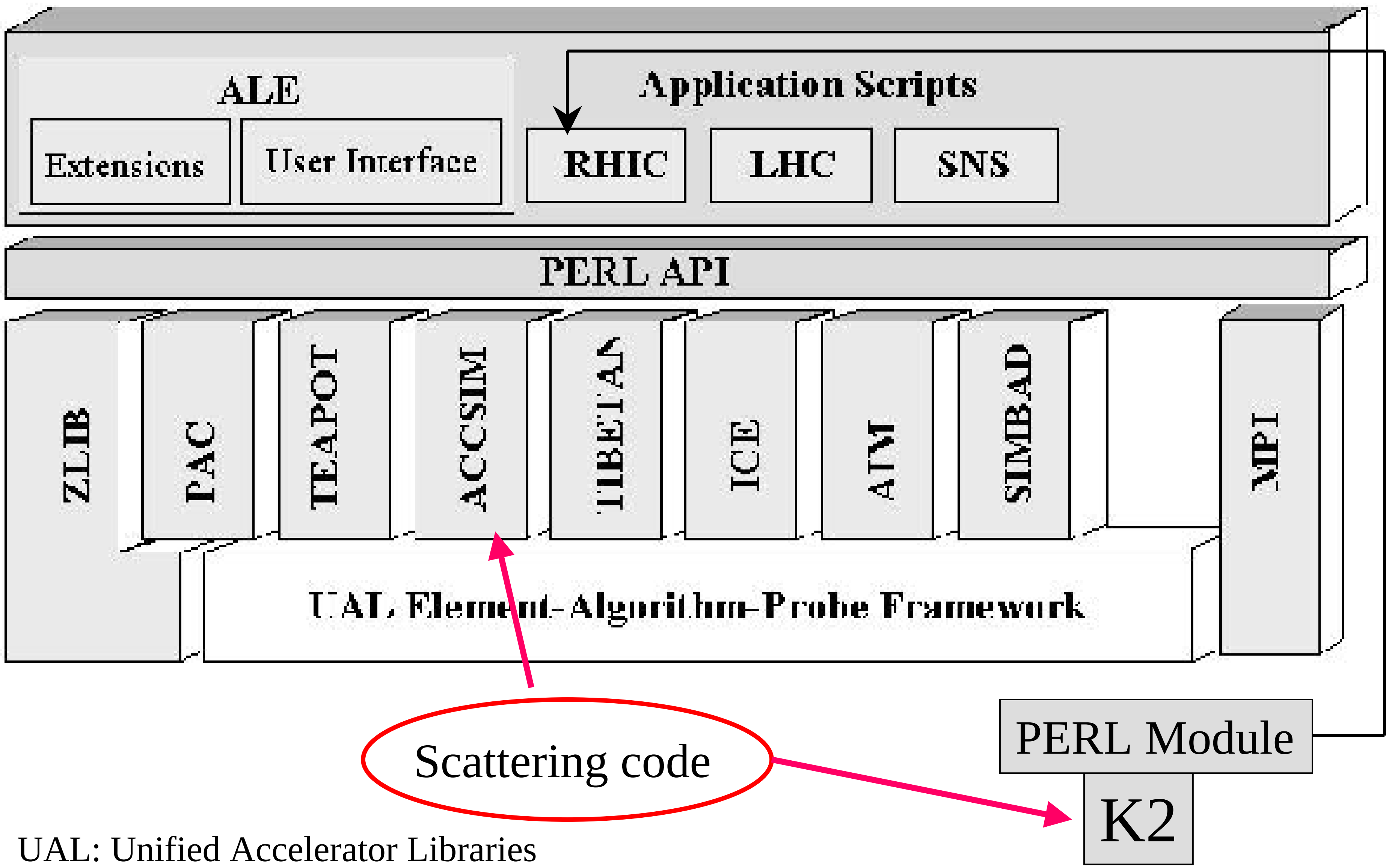
Benchmarking: Goal

Realistic simulation of collimation system and beam loss distribution including the following effects:

- Scattering in collimator jaw.
- Apertures
- Detector background due to collimation.



UAL Architecture



UAL: Unified Accelerator Libraries

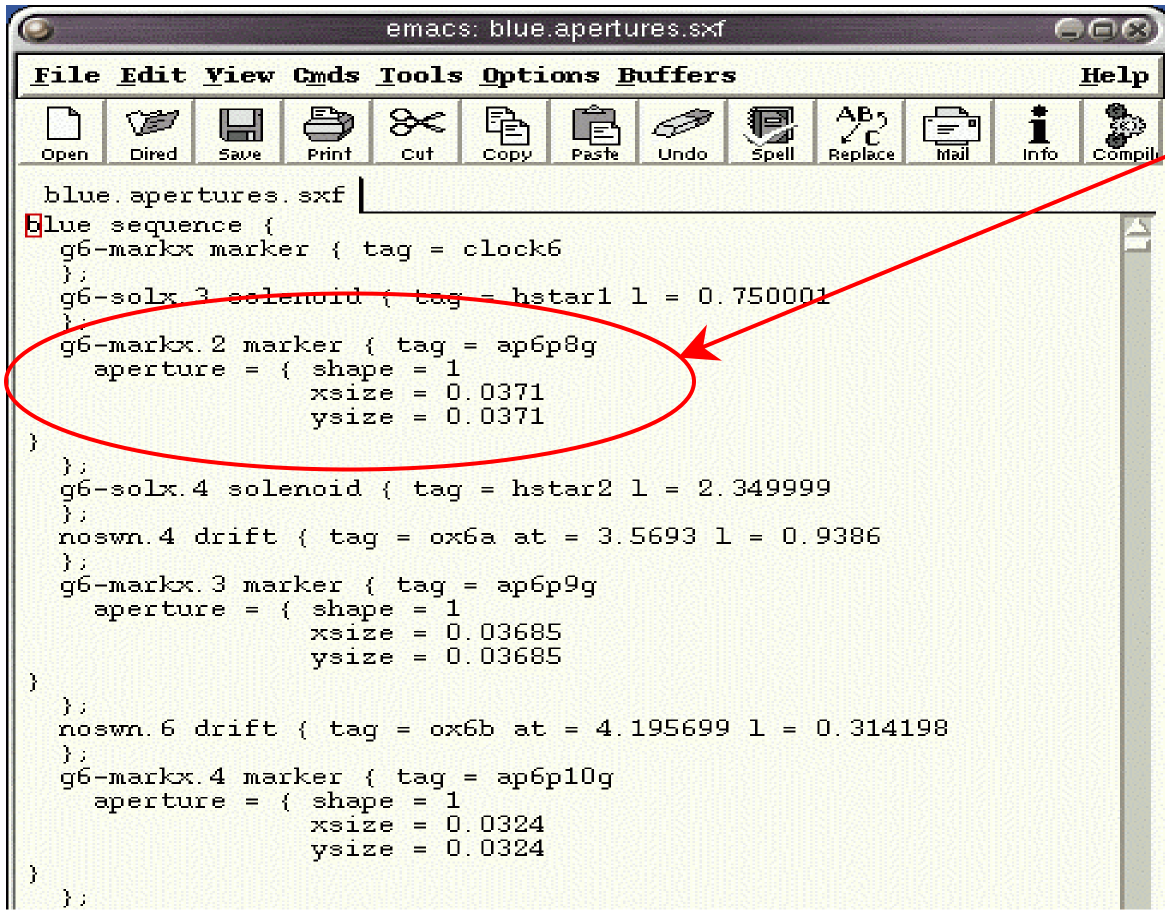
Programs used at BNL for Collimator simulation

- Teapot – used to track particles around accelerator. Part of UAL framework.
- K2 – used to track protons in collimator. Not part of UAL.
- ACCSIM – used to track protons in collimator. Part of UAL.

K2 and ACCSIM simulate protons ONLY. Heavy Ions are not simulated at all. So far, our simulations assume scrapers are perfect absorbers.

Specification of Apertures

A database is maintained that includes ALL machine apertures, down to each and every bellows and tee. A PERL script reads this database to insert this information into lattice file.




```
blue sequence {
  g6-markx marker { tag = clock6
  };
  g6-solx.3 solenoid { tag = hstar1 l = 0.750001
  };
  g6-markx.2 marker { tag = ap6p8g
    aperture = { shape = 1
                 xsize = 0.0371
                 ysize = 0.0371
}
  };
  g6-solx.4 solenoid { tag = hstar2 l = 2.349999
  };
  noswn.4 drift { tag = ox6a at = 3.5693 l = 0.9386
  };
  g6-markx.3 marker { tag = ap6p9g
    aperture = { shape = 1
                 xsize = 0.03685
                 ysize = 0.03685
}
  };
  noswn.6 drift { tag = ox6b at = 4.195699 l = 0.314198
  };
  g6-markx.4 marker { tag = ap6p10g
    aperture = { shape = 1
                 xsize = 0.0324
                 ysize = 0.0324
}
  };
```

Apertures are specified as markers in drifts, or body of magnets

Comparison: Different Codes / Same Results??

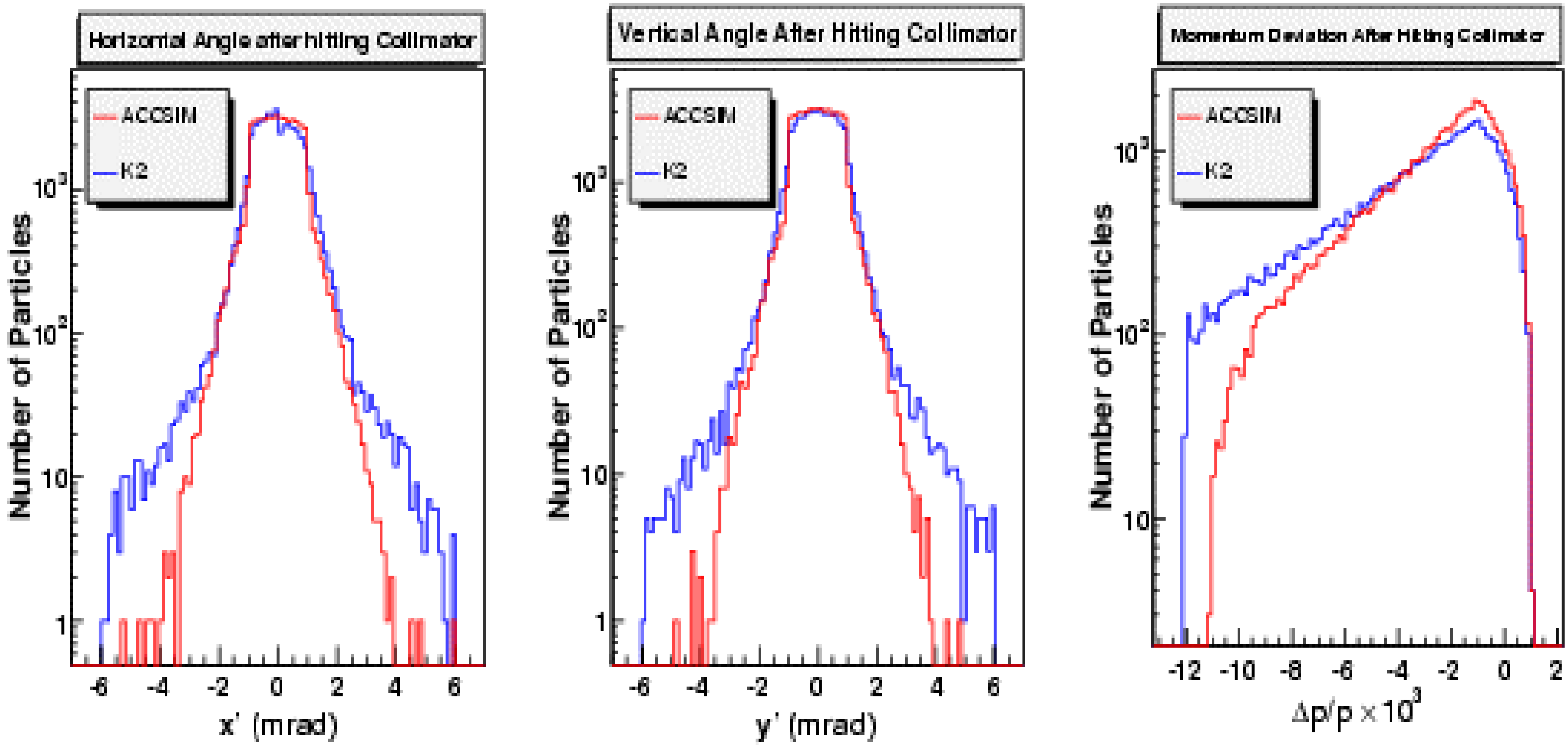
Physicists generally distrust any code they didn’t write (and sometimes the codes they did!)….

Codes modeling the same thing can have different results because:

- More or less physics (include higher orders …)
- The physics is uncertain.
- Same physics, different computation method.
- Different approximations made.
- C++ vs. FORTRAN
- ……

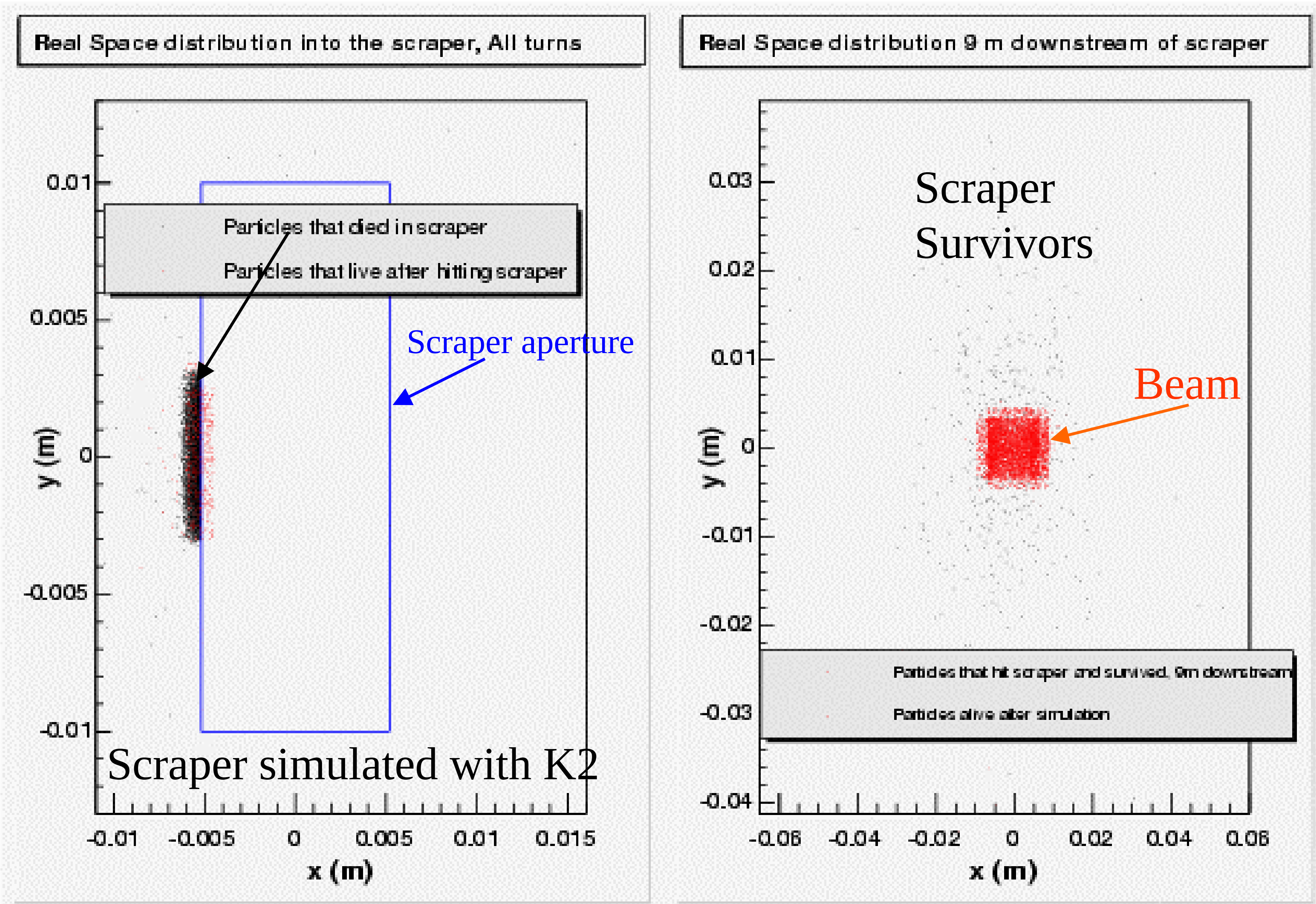
However, in the end we “compute” with experiments and the codes should agree with them. Question: *Can we properly simulate the scattering in the collimator and the loss pattern around a machine?*

Comparison of ACCSIM and K2: Output



K2 angle distributions have larger tails. Approximately 50 particles in the K2 tail are not shown The energy distributions are different. K2 has a much larger tail, 3% of the particles in the K2 tail have $\Delta p/p<-12x10^{3}$.

Particle Distribution After Scraper



Simulation of Loss Distribution

When a particle hits an aperture in TEAPOT, it is flagged as lost. However, the location and turn numbers are not recorded.

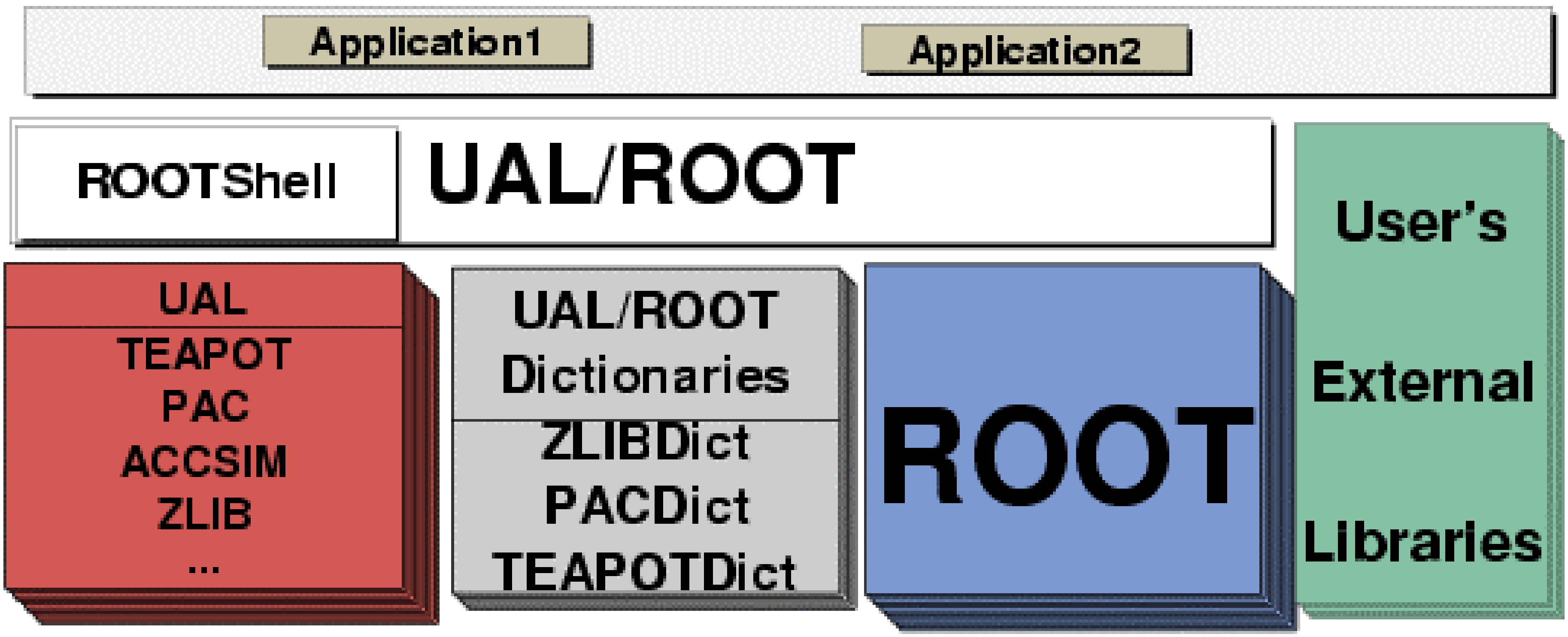
The old solution was to loop over the particle distribution after tracking through the element and write the loss location and turn number to file. – Two loops where one will do – very slow ☹.

A better solution is to have a *LostCollector*. This collector records the particle:

- Number for identification
- Phase space coordinates
- Turn of loss
- s Coordinate of loss

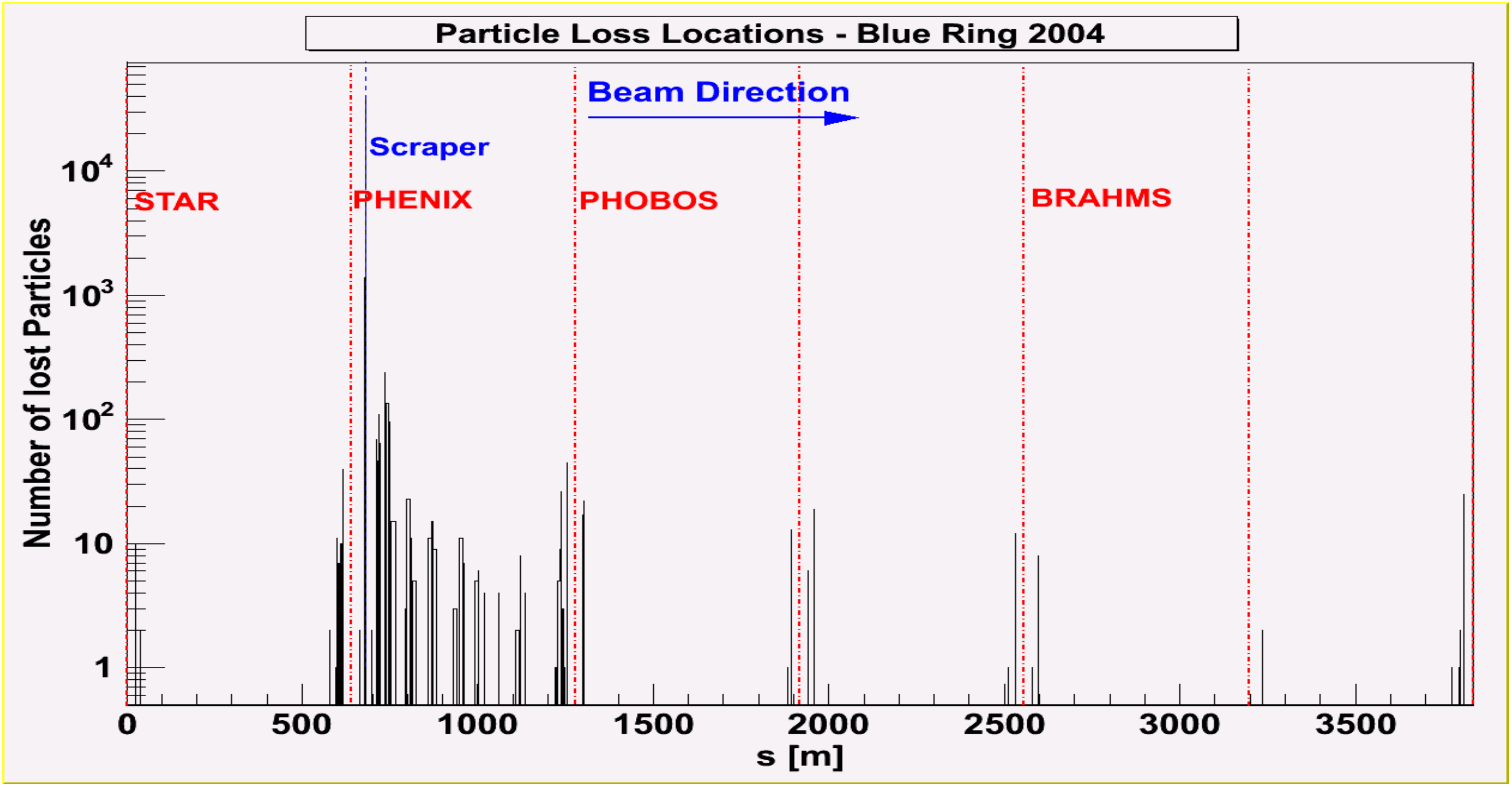
In the tracking loop. This can be written to an ASCII file for later analysis.

UAL/ROOT Architecture



- Additions/edits to tracking UAL do not need a new interface.
- No need to learn different interface and language for each step.
- Go from simulation to pictures in the same C++ program.
- No intermediate ASCII files, no conversion between file formats.
- Allows user to use their own code in the process.

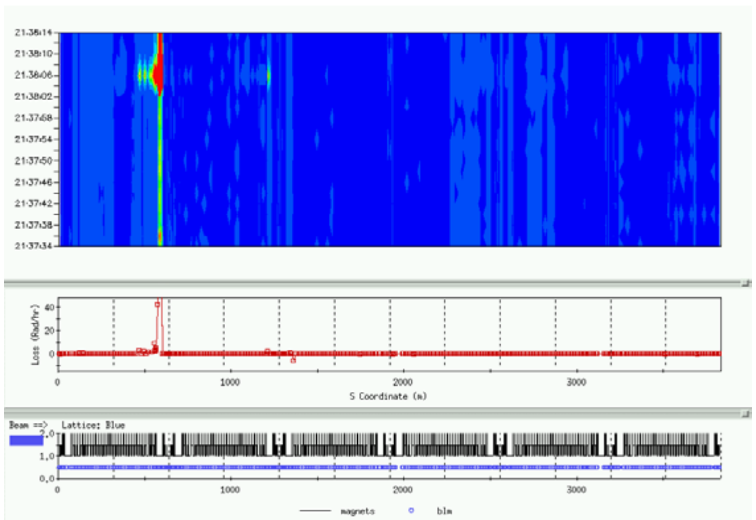
Simulation: Beam Loss Pattern



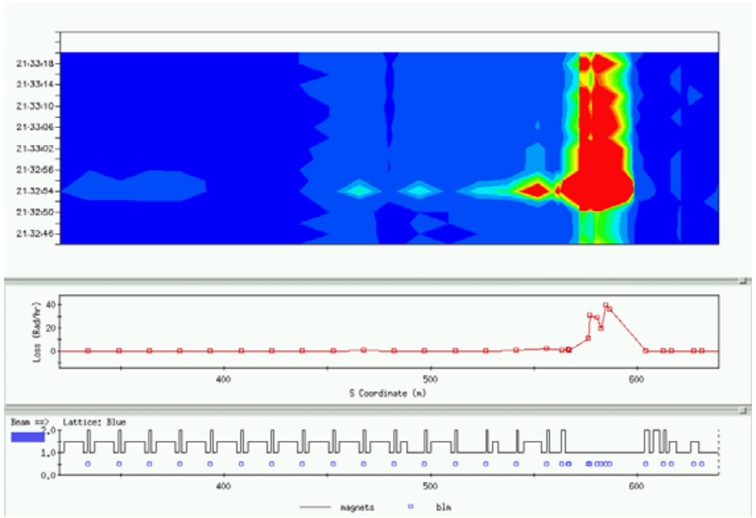
- TEAPOT tracks the particles in lattice, records lost particles
- ACCSIM track particles in scrapers
- ROOT draws the graphs, saves the particle distributions and the graph!

Measured: beam loss pattern (Au beam at injection)

Losses in the yellow ring (Au)



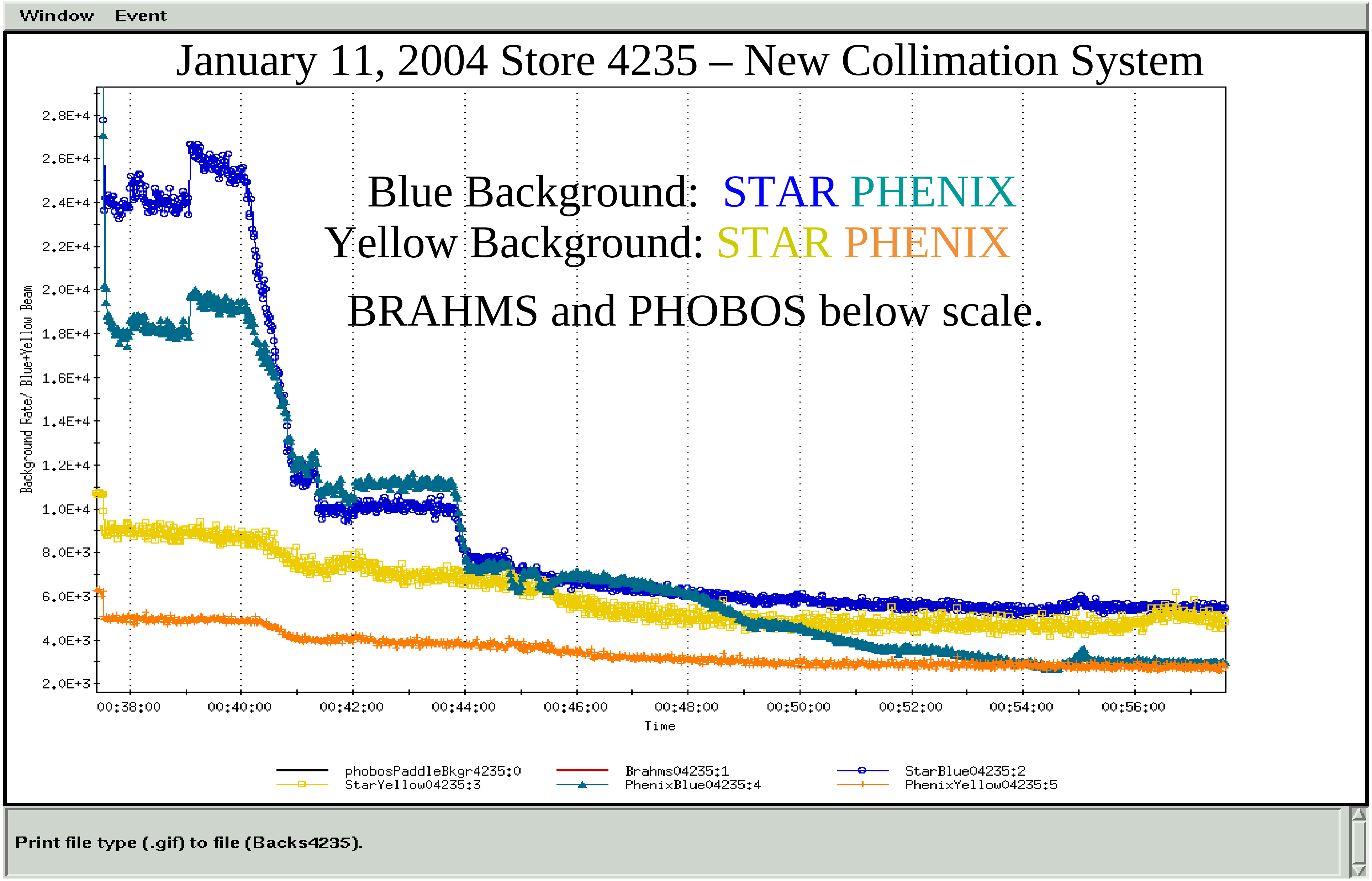
Zoom into collimator area



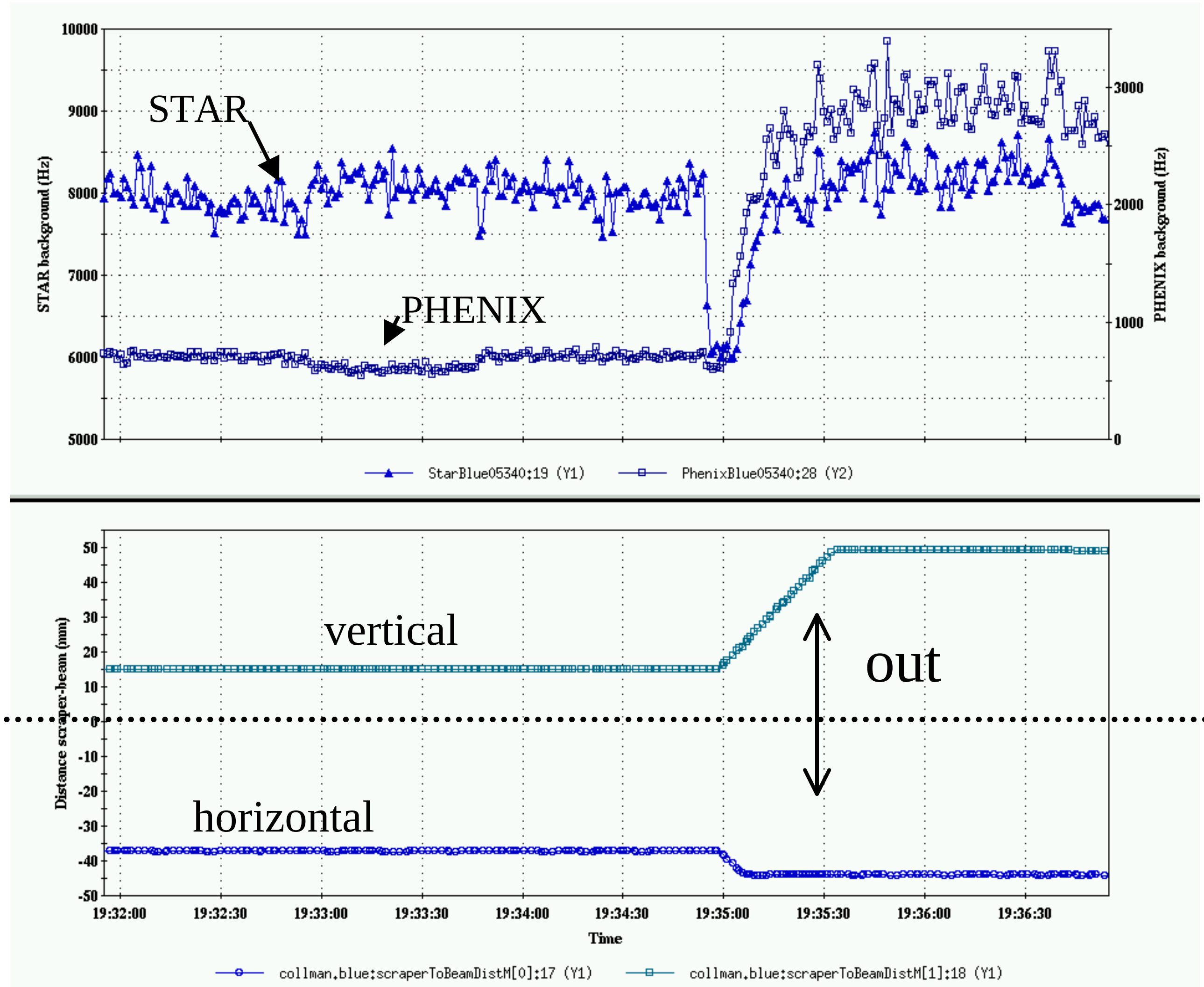
direction of beam

Data taken in a "beam experiment" shift to tune simulation software.
More data available at storage energy and various species (Au, d, p).

Cleaning Efficiencies: STAR and PHENIX Au-Au backgrounds



STAR and PHENIX pp backgrounds



PHENIX background reduction: x5 (only vertical!).

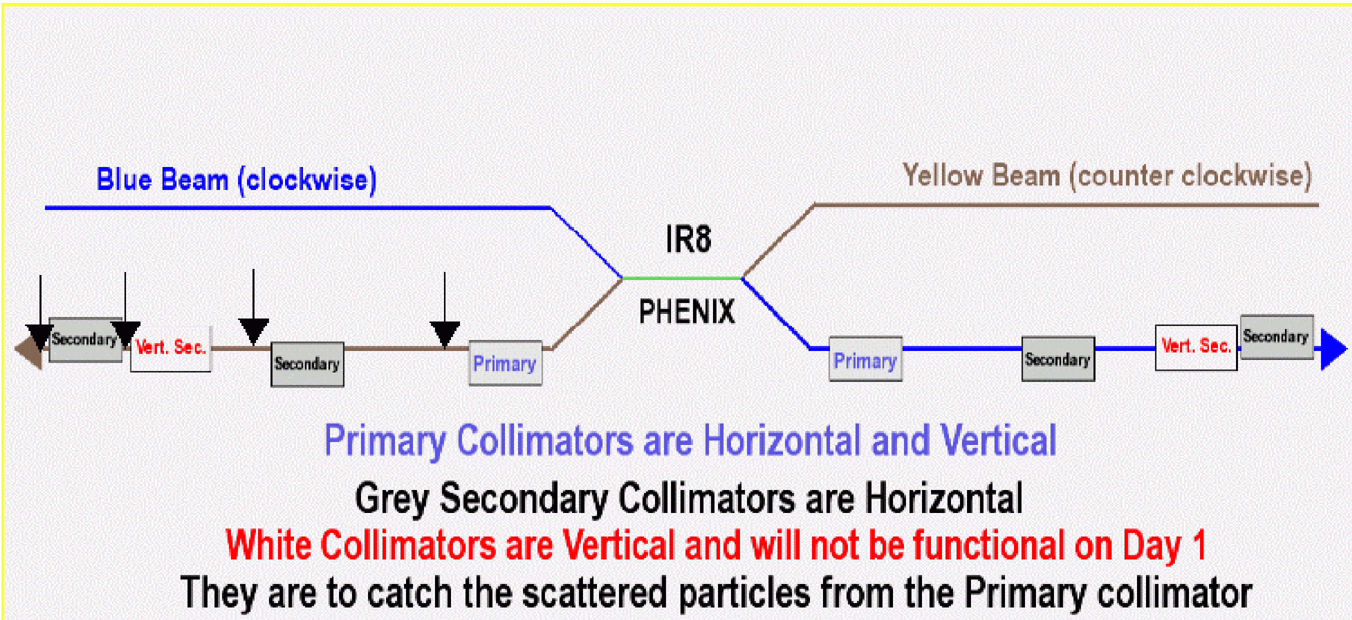
No background reduction in STAR (!)

Fill to fill differences.

Intensity/emittance dependence?

Collimator steering algorithms and procedure

New Collimation System



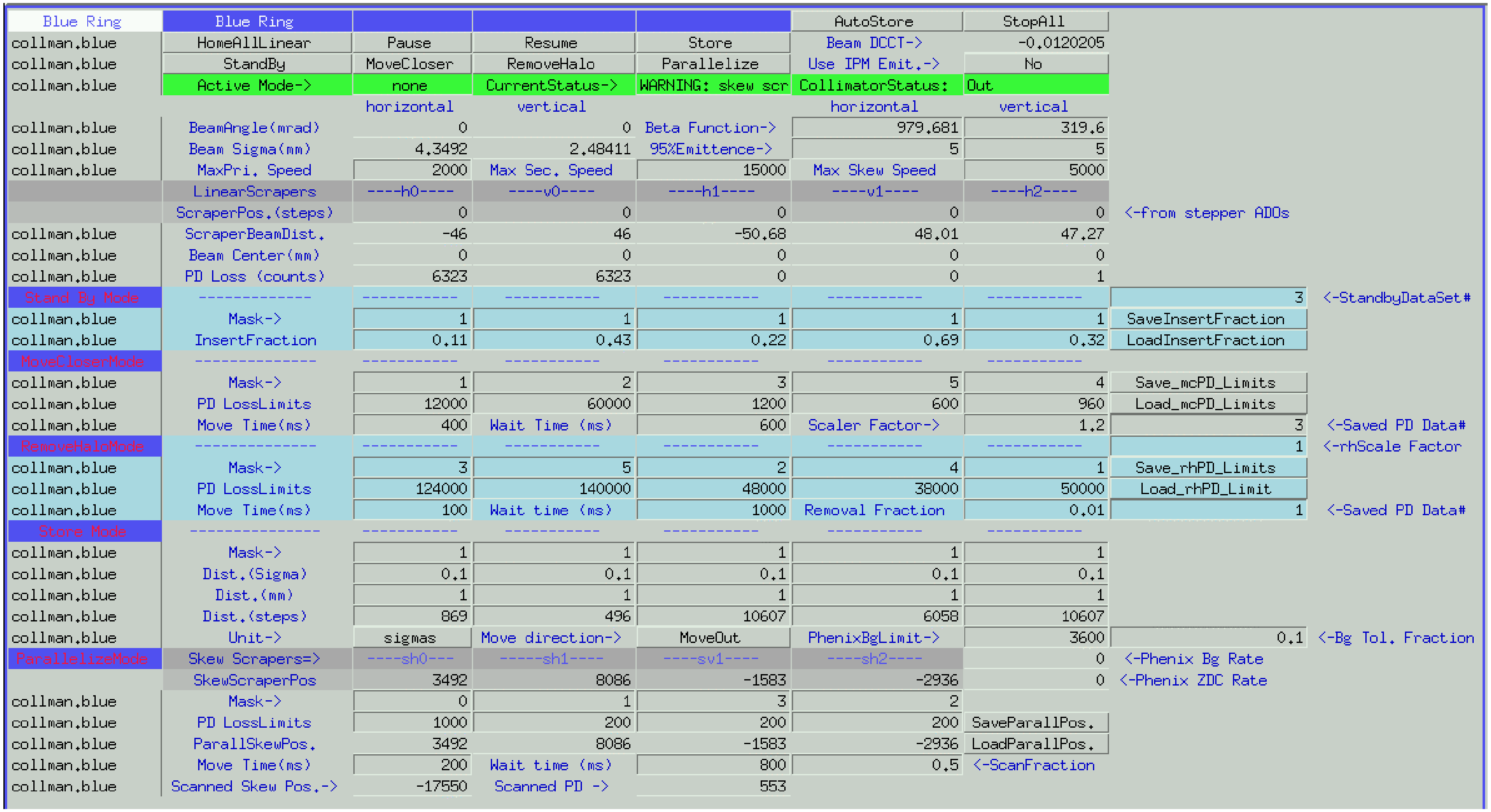
The positions in [m] from the IR are:

primary	41.2
1. secondary H	51.1
secondary V	57.3
2. secondary H	58.3

position PD 1m downstream of collimator (or as much downstream as possible)

RHIC/LHC needs multiple collimator control on the ramp/during the store (where RHIC is much more 'foregiving' and schemes can be tested with beam)
More vertical collimators are installed this shutdown.

RHIC Collimator Steering Software



Blue Ring	Blue Ring				AutoStore	StopAll		
collman.blue	HomeAllLinear	Pause	Resume	Store	Beam DCCT->	-0.0120205		
collman.blue	StandBy	MoveCloser	RemoveHalo	Parallelize	Use IPM Emit.->	No		
collman.blue	Active Mode->	none	CurrentStatus->	WARNING: skew scr	CollimatorStatus:	Out		
		horizontal	vertical		horizontal	vertical		
collman.blue	BeamAngle(mrad)	0	0	Beta Function->	979.681	319.6		
collman.blue	Beam Sigma(mm)	4.3492	2.48411	95%Emittence->	5	5		
collman.blue	MaxPri. Speed	2000	Max Sec. Speed	15000	Max Skew Speed	5000		
	LinearScrapers	----h0----	----v0----	----h1----	----v1----	----h2----		
	ScraperPos.(steps)	0	0	0	0	0	<-from stepper ADOs	
collman.blue	ScraperBeamDist.	-46	46	-50.68	48.01	47.27		
collman.blue	Beam Center(mm)	0	0	0	0	0		
collman.blue	PD Loss (counts)	6323	6323	0	0	1		
Stand By Mode	-------------	-----------	-----------	-----------	-----------	-----------	3	<-StandbyDataSet#
collman.blue	Mask->	1	1	1	1	1	SaveInsertFraction	
collman.blue	InsertFraction	0.11	0.43	0.22	0.69	0.32	LoadInsertFraction	
MoveCloserMode	-------------	-----------	-----------	-----------	-----------	-----------		
collman.blue	Mask->	1	2	3	5	4	Save_mcPD_Limits	
collman.blue	PD LossLimits	12000	60000	1200	600	960	Load_mcPD_Limits	
collman.blue	Move Time(ms)	400	Wait Time (ms)	600	Scaler Factor->	1.2	3	<-Saved PD Data#
RemoveHaloMode	-------------	-----------	-----------	-----------	-----------	-----------	1	<-rhScale Factor
collman.blue	Mask->	3	5	2	4	1	Save_rhPD_Limits	
collman.blue	PD LossLimits	124000	140000	48000	38000	50000	Load_rhPD_Limit	
collman.blue	Move Time(ms)	100	Wait time (ms)	1000	Removal Fraction	0.01	1	<-Saved PD Data#
Store Mode	-------------	-----------	-----------	-----------	-----------	-----------		
collman.blue	Mask->	1	1	1	1	1		
collman.blue	Dist.(Sigma)	0.1	0.1	0.1	0.1	0.1		
collman.blue	Dist.(mm)	1	1	1	1	1		
collman.blue	Dist.(steps)	869	496	10607	6058	10607		
collman.blue	Unit->	sigmas	Move direction->	MoveOut	PhenixBgLimit->	3600	0.1	<-Bg Tol. Fraction
ParallelizeMode	Skew Scrapers=>	----sh0---	-----sh1----	----sv1----	----sh2----	0	<-Phenix Bg Rate	
	SkewScraperPos	3492	8086	-1583	-2936	0	<-Phenix ZDC Rate	
collman.blue	Mask->	0	1	3	2			
collman.blue	PD LossLimits	1000	200	200	200	SaveParallPos.		
collman.blue	ParallSkewPos.	3492	8086	-1583	-2936	LoadParallPos.		
collman.blue	Move Time(ms)	200	Wait time (ms)	800	0.5	<-ScanFraction		
collman.blue	Scanned Skew Pos.->	-17550	Scanned PD ->	553				

Flexible design (similar to the Tevatron -> D. Still ☺)

Feedback based on local loss monitors, exp. backgrounds and machine optics.

Planned Collimation Activities

- Multiple turn simulations with apertures (bench marking):

i. CERN collimation review Jun30 – Jul 02 04 at CERN
ii. Late summer: CERN pd & BNL specify requirements and check out existing code/platform
iii. Now->: work on common simulation platform (ROOT & Fluka & Mars & UAL & AccSim & …)
iv. Fall: SPS test beam at CERN
v. FY05: CERN pd here for a couple or months (2?) to analyze the existing loss pattern/aperture data from RHIC, benchmark existing codes and simulations (report)
vi. During FY05: get new post doc (50% RHIC, 50% LHC)
vii. During run in FY05: dedicated study for cleaning efficiency (report 06/05)

- Other topics:

- Commissioning/operation (concepts of motion control for multiple jaws) during next run (report late spring/summer 05)
- BLM calibration (if not done at SPS, requires some RHIC beam time & BI) ?

Summary

- Simulations of loss distributions have been done using K2, ACCSIM, and TEAPOT. Experimental data remain to be analyzed.
- UAL provides ability to simulate loss distributions, including collimator scattering with ACCSIM (K2).
- UAL/ROOT provides the ability analyze simulation results without the need to learn/maintain multiple interfaces to multiple programs.
- Questions remain about which programs accurately simulate the physics of proton scattering in the collimator.
- What about Heavy Ion scattering??
- Collimation efficiency data as a function of intensity, emittance, energy, beta function and species can be studied (data available).
- Platform to implement different setup strategies is available.